Fish Migration and Passage

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USE OF THE SAN FRANCISCO ESTUARY

BY JUVENILE CHINOOK SALMON

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EXTENDED ABSTRACT ONLY - DO NOT CITE

Estuaries have been found to serve important nursery and rearing functions for juvenile salmonids emigrating from streams in the Pacific Northwest of North America (Reimers, 1973; Simenstad et al., 1982; Healey, 1991). The San Francisco Estuary, the largest estuary on the West Coast, is a segment in the migration path of juvenile chinook salmon (*Oncorhynchus tshawytscha*) leaving natal streams in the Sacramento - San Joaquin River system of California=s Central Valley. All four chinook salmon runs are imperiled: the winter and spring runs are listed under the U.S. Endangered Species Act, and the fall and late-fall runs are candidates for listing. Although dams and water diversions in the Central Valley clearly play significant roles in the stocks= decline, the influence of transiting the highly modified and urbanized San Francisco Estuary is unknown and may contribute to reduced survival. To address this issue, a multiyear study was conducted on the growth and development of juvenile chinook during their emigration through the Estuary, and the influences of environmental factors on their physiological dynamics. Aspects of that investigation are presented here.

Data in this report are from juvenile chinook salmon collected in 1997 during May and June, the period of greatest abundance in the Estuary (Kjelson et al.,1982), at four locations spanning the saline portion of the Estuary (km=s 68, 46, 26, and 3 from the Estuary exit) and in the Gulf of the Farallones, the coastal waters seaward of the Estuary exit at the Golden Gate. Juvenile salmon were collected by trawl and held on ice until returned to the laboratory for analyses. Size, age (otolith increments), stomach contents, and concentrations of lipid classes and total protein were determined. Data were analyzed for variability among locations and capture dates by the general linear model of analysis of variance and by Tukey=s studentized range test.

Each sampling location was visited more than once on two successive sweeps of the Estuary, starting at the confluence of the Sacramento and San Joaquin Rivers (km 68) and ending at or near the exit at the Golden Gate (km 3). There were no statistically significant trends in size, age, lipid, and protein variables by sampling date at any location; consequently data for each location from both sweeps were combined for further analysis.

Juvenile chinook were 136 " 2 d post-hatching when they entered the Estuary (Fig. 1c). Based on the difference between mean otolith increment counts of fish from km 68 and km 3, they spent about 40 d transiting the 65-km span of the Estuary, resulting in a calculated migration rate of 1.6 km/d. Data from coded-wire tagged fish revealed a modal migration rate of 2.6 km/d (n = 17).

While in the Estuary, young chinook salmon grew very little, gaining only 7 mm fork length and 0.9 g weight on average (Fig. 1a & 1b). Once in marine waters of the Gulf of the Farallones, however, growth was rapid. Changes in size within the Estuary were not statistically significant, whereas chinook from coastal waters were longer ($P <$ 0.0001) and heavier ($P < 0.001$) than those from the Estuary.

In addition to insignificant growth while in the Estuary, juvenile salmon experienced declining condition (Fig. 2) and no accumulation of lipids or protein. Once in the ocean, however, condition recovered ($P < 0.001$) and triacylglycerols, the primary energy store, were depleted ($P < 0.0005$). Other lipid classes (polar lipids, cholesterol, nonesterified fatty acids, and steryl/wax esters) were unchanged during Estuary transit and ocean residence.

Emigrating salmon appeared to feed more while in the Estuary than prior to entry. More than 80% of individuals in the Estuary contained food in their stomachs whereas 50% had stomach contents when entering the Estuary. There was a progressive change in the importance of prey, from invertebrates to fish larvae, as young chinook migrated from freshwater to the ocean. Feeding was intensified in the ocean: stomach contents were about 0.9% of body weight in ocean fish contrasted with 0.5% in fish from within the Estuary.

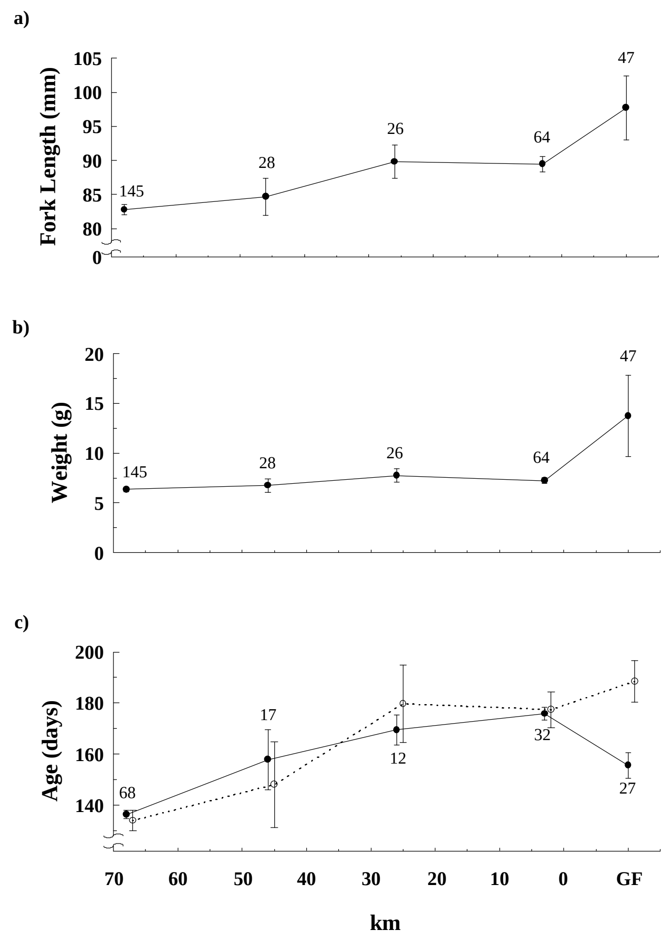

Figure 1. Mean (±SE) (a) fork lengths (FL), (b) weights, and (c) ages of juvenile chinook salmon from locations within the San Francisco Estuary (km's 68, 46, 26, 3) and Gulf of the Farallones (GF). Open circles and dashed line in (c) represent calculated ages for all salmon collected at each location from regression:
Age = 26.83 + 1.48 (FL). Numbers near means are sample sizes.